from Paris in 1951. The intention is evidently to introduce the main concepts and results of experimental embryology to students. In the 1930s this subject seemed to have a brilliant future; but, with the disappearance of Spemann's organizer concept, and the inadequacy of later attempts to develop fruitful generalizations about developmental "mechanics", disappointment set in. Some of those who to-day might have been promoting the growth of a major branch of experimental biology, have instead turned to genetics or wound healing or immunology as more profitable subjects of research. In university departments of zoology, experimental embryology is consequently often taught only in a perfunctory way or not at all.

A stimulating introduction would, then, have been most welcome, and parts of this book fulfil the need very well. For instance, it is made very clear that study of the chemistry of embryonic cells is the most likely means by which the whole subject may be revived. Unexpectedly, a good deal of space is devoted to both biochemical and morphological researches on the early development of mammals—researches which are not yet generally familiar to anatomists or zoologists. But such passages have to be sought among much longer ones of smaller use. Consider the following:

> In the mitochondria (the study of which has benefited specially from the technique of fractional centrifugation, notably in the work of A. Claude) the cytologist must picture to himself the enzymes and intermediaries of the tricarboxylic acid (Krebs) cycle and of the cytochrome oxidase system. In the nucleus as well as in the cytoplasm, he must envisage the role of high energy-value co-enzymes, notably the three phosphoric esters of adenosine, co-enzymes I, II, A, and flavine and pyridine derivatives. And in both cytoplasm and nucleus, the cytologist will be confronted with transformations mediated by nucleic acids, or by glycoprotein or mucopolysaccharide complexes.

The student, having got through that, may reasonably expect to find an account of actual observations which require him to envisage the co-enzymes and the rest. But this is not vouchsafed: further paragraphs of similar generality follow, and the evidence on which the statements are based is only occasionally and sparsely divulged. Similarly, the reader is told that terms such as "differentiation", "growth" and "organogenesis" may be used only if they are carefully defined. Yet in the passage that follows only "organogenesis" is provided with anything that can be recognized as a definition.

This short book resembles an early embryo, in which few of the major structures are yet sharply distinct. One knows that much "information" is present, but its import can be only dimly discerned. Unfortunately, the book, unlike a viable embryo, is not undergoing a process of further morphogenesis. Had the translator, instead of keeping to her proper task, indulged in extensive experimental interference, the result might have been a much more useful contribution to the understanding of embryology.

S. A. B.

EVOLUTION

Cannon, H. Graham. *The Evolution of Living Things.* Manchester, 1958. Manchester University Press. Pp. x + 180. Price 12s. 6d.

IF WE BELIEVE the notice on the jacket, this book is something of an event. A zoologist challenges first the *dictum* (sic) that blind chance is the mainspring of evolution, and secondly the suggestion that the gene theory can possibly account for new characters that appear during evolution or for the harmonious functioning of existing marvellously adapted parts. Professor Cannon "demonstrates that there must be a directive force which controls evolution and that that force must reside within the organism". Before dealing with the essentials of the book it is helpful to consider some general points which bear on this subject.

The success of Darwin's theory of evolution by natural selection depended partly on contemporary interest, but the theory has survived as an explanation of progressive change because it is a logical consequence of a set of observations; Malthus therefore competition; variation therefore selection; inheritance therefore cumulative changes; breeds of domestic animals therefore also natural diversity as a consequence of similar causes. Following Darwin the interest next centred round the nature of variations and its inheritance. There grew up the English biometrical school. At the same time Bateson

collected data on discontinuous variation, Mendel's conclusions were found to be valid for a wide variety of organisms. From observations of the distribution of variations among progeny it became possible to show that some characters are inherited as units which can be arranged as a number of linear series corresponding with the chromosome lengths. The results of many breeding experiments could then be predicted.

However the geneticists faced three limitations. First they were able only to experiment on variations which happened to appear and could say nothing about the origin of mutations of different kinds apart from the description of factors which influence the frequency of mutations. Under these circumstances the correct and humble attitude is to make no inferences of ordered processes which could underly the direction of mutation.

Secondly, the geneticists were limited to observations of inheritance of differences, which in many instances are minor defects. The breeding populations must live long enough to provide data over several generations and therefore the inheritance of features which spring from widespread embryological processes or essential biochemical factors could not be studied.

Thirdly, a characteristic of living organisms is that essential metabolic processes are maintained in approximately the same steady state and this is probably achieved in all cases by self-regulating feed-back systems of chemical reactions. The structures which we see are partly the solid products and partly the solid components of these reactions. The essential machine itself is what we are really interested in, and the minor changes in pattern of the products are less important. The origin of the essential wholeness of the organism lies in these regulating mechanisms, which control structure as they control function and *vice-versa*. Yet analysis of such systems into component mechanisms can only proceed if a regulating mechanism is inactivated, i.e., a feed-back loop is opened, and as soon as this is done the features of interest disappear. In an artificially constructed system, as the number of regulating mechanisms increases so the total behaviour can be derived with less certainty from the behaviour of the components. In living systems it is fair to say that we know only a few of the rules of action of components, and can recognize only part of the pattern of organization. The control of embryonic development is the relevant example of regulation, for the genetic control of development is the foundation of adult form and hence the matrix of evolution.

Professor Cannon's main purpose is to show "that what is referred to as the orthodox theory of genetics falls far short of explaining that main problem of philosophical biology, evolution". Having carefully read through the whole book I can find no account of the deficiency. The application of genetical discoveries to evolutionary theory centres round R. A. Fisher's book *The Genetical Theory of Natural Selection* amplified by a great volume of recent data from actual population studies. The present conclusions are clearly set out in many places but are not critically examined by Cannon: they are dismissed with such phrases as "It [Mendelism] dealt with characters of a different order from the continuous variations of Darwin" and "something which hands on their constitution to their descendants. This process cannot, as I have shown, be anything to do with the gene complex". His reason why the genes cannot be of importance for the inheritance of "the great central something" is briefly that genetics is concerned with minor deleterious differences, and evolution is not, therefore evolution is not concerned with genetics. However, Professor Cannon omits the evidence to show why evolution is *not* concerned with minor differences.

The actual main content of Professor Cannon's book is a suggestion of two distinct kinds of variation, the first consisting of accidental minor characters which are inherited via the chromosomal mechanism, the second being purposeful functional mechanisms such as those which interact with the environment as in feeding, respiration, locomotion and so forth. The latter are supposed to be inherited by some protoplasmic activity (which has so far not been studied) which can relate their appearance and their harmonious interrelations to the functional needs of the organism in accordance with a "*physico-chemical law*" related to Le Chatelier's principle. (Le Chatelier's principle states that systems in equilibrium respond to external

changes by a shift of the equilibrium in a direction that tends to restore the *status quo*). The non-accidental appearance of harmonious inter-relations of complicated functional mechanisms is the essential part of Lamarck's suggestions, which Professor Cannon now exhumes and presents seriously. If true, the consequences are so great that the supporting evidence must be carefully examined.

The supporting evidence is not presented although there are many statements that overwhelming evidence is given. What is actually presented is a set of descriptions of the very phenomena which the proposed explanatory concepts purport to explain. There is no evidence at all that the suggested explanatory concept (Lamarckism) is the right explanation; no primary data on what lies behind the admittedly wonderful and intricate animals to which we are introduced. This is the course which Paley, and many others, have taken. The philosophy of "It would work if we postulate so-and-so" has explanatory value only when continually fed on new observations, checked by experiments and vindicated by correct predictions.

The suggested mechanism, Chatelier's principle, does not apply because the living systems are steady states, not equilibrium positions. To illustrate my meaning take T. H. Huxley's old analogy of life, a candle-flame. The outline of the flame is determined by a steady state; now increase the ambient temperature and the wax will volatize more readily, thus tending to raise the ambient temperature still more. You can, of course, say that the new form is an adaptation to the changed environment, but really what we have is an incipient explosion. A consequence of any theory of Lamarckism is that changes would occur in a direction which depends on a measure of *future* efficiency. However economical this may be (and there is no actual evidence of economy of generation) a time relation is implied which upsets all our notions of how the universe works.

One can forgive the small errors such as those that relate to the feeding habits of stick insects, the coprophagy of rabbits, the nuclei of bacteria, the reactions of frogs and so forth. Zoology is a large subject and the essential argument of the book does not demand that the examples wholly refer to the real world. The fundamental errors of judgement are more serious, for example "It is easy to imagine mutations that will behave in any way we please" may be a correct description of Professor Cannon's imaginative powers but in fact no example of such a mutation is known, and this quoted statement is taken as evidence against current genetical theory. Respect for Natural Laws (which in this instance are proposed, not derived) is illustrated (p. 148) as follows: "They [Bacteria] are smaller than the latter [Protozoa] and this agrees with Lamarck's first law". From this the conclusion that Protozoa evolve from Bacteria which anticipate that they need nuclei is implicit in the surrounding pages. The evolution of these Bacteria from simpler forms could not be a Mendelian process because *chromosomes* are absent, and therefore the existence of evolution in organisms without a nucleus *shows that* inheritance of large adaptive characters is cytoplasmic in animals (p. 163-4) having nuclei. This illogical development of the conclusion to the book is unfortunately not substantiated by observations which bear upon the points at issue. The erudition has a slightly dusty character to one who is familiar with work on the exchange of chromatic material between bacteria individuals, work on gene mapping in bacteriophage, the demonstrations of the importance of the nucleus by nuclear transfer experiments, and the fundamental nature of mutations as illustrated by the biochemical mutants of fungi. These whole fields of knowledge in direct contradiction of Professor Cannon's main points are either ignored or not known by him.

To account for the persistence of ideas of directed change in evolution is not difficult: they spring from intuition rather than observation. Belief in a Director implies direction. The converse argument is the one which we are usually given, but to derive the Director from the apparent direction perennially satisfies neither those who *for other reasons* would like to be satisfied nor those who feel that scientific theories must have no emotional content. I do not suggest that our present theory of natural selection is complete, or that Lamarckian experiments should not be carried out, but I have a feeling that future explanation of inheritance

of the inter-relationships between intricate animal parts and their origins in development will never be based on the suggestions of Lamarck.

ADRIAN HORRIDGE

FERTILITY

United Nations. *Recent Trends in Fertility in Industralized Countries.* Population Studies No. 27. New York, 1958. Pp. xi + 182. Price 14s.

THE COURSE of birth rates and other measures of fertility in Great Britain has shown more irregularity during the past two or three decades than in any similar earlier period for which statistics are available, and much ingenuity has been expended in attempting to explain the various recorded changes or apparent changes of trend. Similar developments have occurred in other Western countries, and it is therefore reasonable to turn to international comparisons in an effort to ascertain the most important factors influencing the numbers of births. In 1951, Bernardo Colombo studied the statistics of eighteen countries in which the birth rate had recovered from a decline* and attempted to characterize the change as being a reaction of an instinctive nature attributable to War — a "triumph of the instincts . . . over hedonistic reasoning". Subsequent happenings have suggested that is too simple a picture, and the United Nations demographers have not sought to find so straightforward a solution to their careful and thorough analysis. It is curious, however, that Colombo's work is not mentioned in the text, or even referred to in the extensive Bibliography included at the end of the book.

In the final words of the Introduction, "the interpretation of the current situation must necessarily remain fragmentary". The reason for this lies in the nature of the statistics available. Accurate basic data such as the numbers of births and marriages and the size of the population are collected in most industrialized countries, and these serve to establish the essential facts. They are, however, insufficiently detailed to reveal the behaviour of different cohorts and classes of the population or to measure the effects of current economic and political developments. Only some of the countries in question can provide the more complex data needed for demographically sophisticated analyses, and hardly any two of them can supply the same type of information: for instance one will have material allowing the study of birth cohorts while another amasses particulars relating only to different sets of marriages. Again, these elaborations are often of too recent an origin to permit the drawing of sufficiently broad conclusions.

Members of the Eugenics Society are interested in differential fertility, and especially to know whether the recent signs in Great Britain of some increase in family size among the upper social classes finds any counterpart in happenings in Europe and the United States of America. Data of this kind are, however, particularly fragmentary and the United Nations analysis does not at any time descend from the national to a local or a "class" level. As the Foreword says, "the present analysis of the demographic factors should be completed by an examination of the economic, social and political conditions which have been associated with the changes in fertility", and it is hoped that others will undertake studies of these aspects.

Within the limited framework chosen, however, the United Nations study keeps up the high standard of other population studies from the same source. It gives a carefully-weighed comparison of international fertility data that will be of great value to demographers in industrialized countries and will be of special help to them in making their judgements and interpretations of the significance of their own national family statistics.

P. R. C.

GENETICS

Sheppard, P. M. *Natural Selection and Heredity.* London, 1958. Hutchinson. Pp. 212. Price 18s.

THIS BOOK, published in the centenary year of the Darwin-Wallace papers, is a most authoritative and attractively written account of natural selection. Dr. Philip Sheppard has succeeded in that most difficult of feats—writing a scientific book which can be read with pleasure and understanding by those new to the subject. A

* *La Recente Inversione nella Tendenza della Natalità.* Padua, 1951. Cedam.